DECEMBER 3, 2015

Michigan GIS Users Group
GIS - Professionals

THE MICHIGAN GEOLOGICAL SURVEY

HOW CAN WE ACCELERATE GEOLOGIC MAPPING? WHAT IS NEEDED TO MAP RESOURCES!

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1

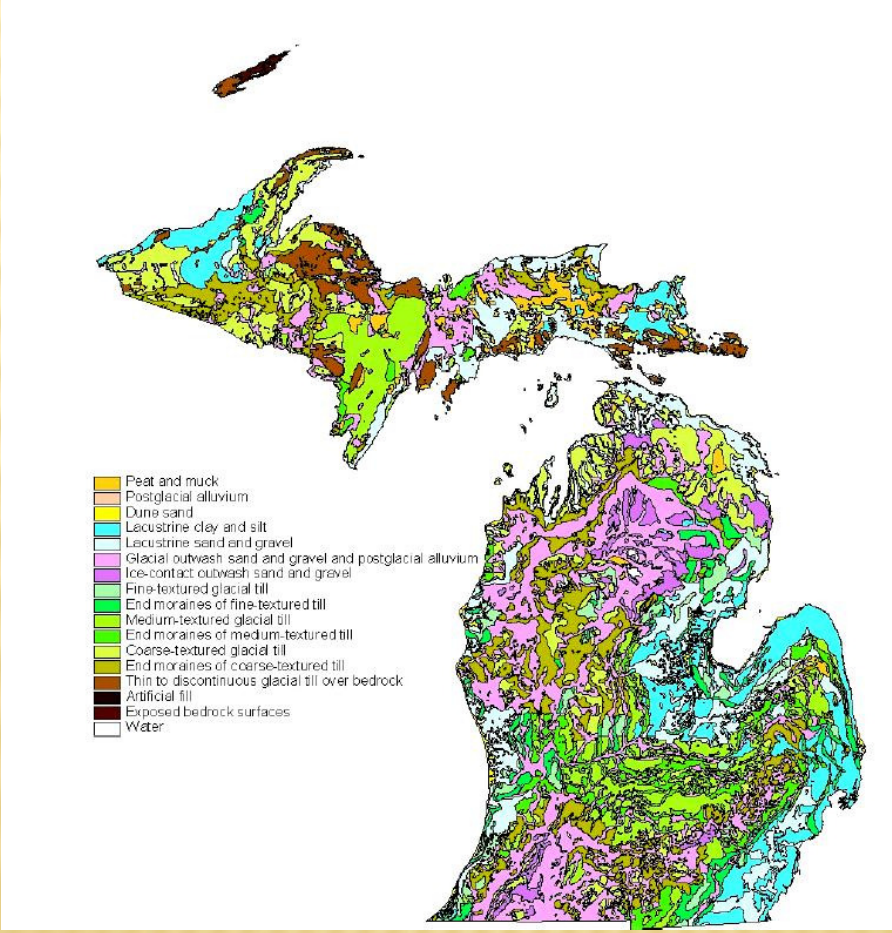
MICHIGAN GEOLOGICAL SURVEY

A Geological Survey – Is Geology

- Mineral resources, groundwater, aggregates, energy, geo-hazards, geologic research and publications is the Survey
  - 30+ years - Michigan - no Survey functions
  - October 2011, Governor assigned Survey to Western Michigan University, Geosciences Department
- Validated geologic data = Return on Investment (ROI)
- Geologic Repository for Research and Education – 30 years of documented ROI (MGRRE) at WMU, now the Survey

2

STATE 1982 QUATERNARY SURFICIAL GEOLOGIC MAP



Leverett & Taylor – 1915*, updated by

Helen Martin, 1955

Farrand & Bell, 1982 was a soils update

This outdated map is used for assessing many of Michigan resources.

*1915 -Mapping was done from horses, wagons , walking and early vehicles

STATE GEOLOGIC MAPPING-GENERALIZED

<10% OF MICHIGAN (QUADS) IN THE LP AND MINIMAL AREAS OF THE UP HAS HAD THE SURFACE AND SUBSURFACE MAPPED AND PUBLISHED MOSTLY BY THE SURVEY IN THE LAST 20 +YEARS.

Blue – County surficial and EDMAP, which is a USGS student mapping program, primarily surficial.
Green – County compilation, Surficial by USGS or others.

Less than 10 % Detailed with subsurface

MGS mapping.

* **Quads (~56 Sq Mi)**

- GLGMC
- STATEMAP
- Black - Surface only with validation of borings
- **Red – surface + some subsurface drilling / geology**

4

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This is the real summary of mapping of the surface and subsurface by MGS, USGS or others.

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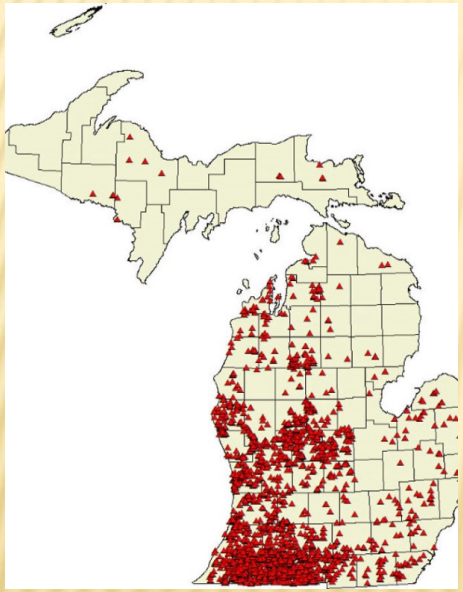
WWAT APPLICATIONS VS DETAILED GEOLOGIC MAPS

Approximately 90% of the LP groundwater comes from glacial material

WWAT Applications through 2014 for comparison



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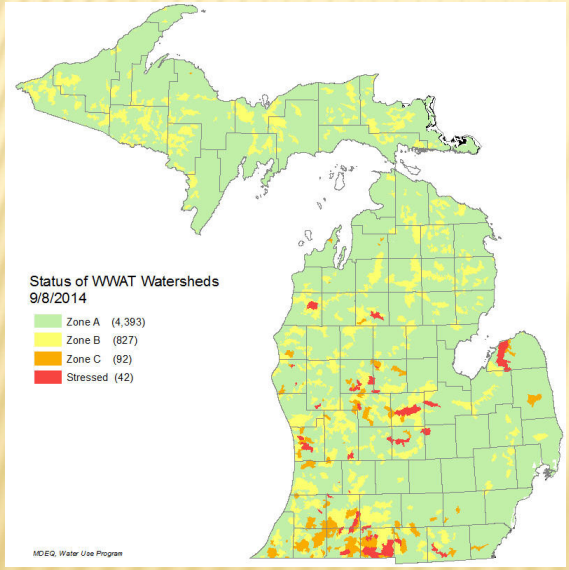
6

WATERSHEDS VS DETAILED GEOLOGIC MAPPING

<10% OF MICHIGAN (QUADS) IN THE LP AND MINIMAL AREAS OF THE UP HAS HAD THE SURFACE AND SUBSURFACE MAPPED AND PUBLISHED BY THE SURVEY IN THE LAST 18 +YEARS.

Location of stressed aquifers in Michigan, per Mi WATT.



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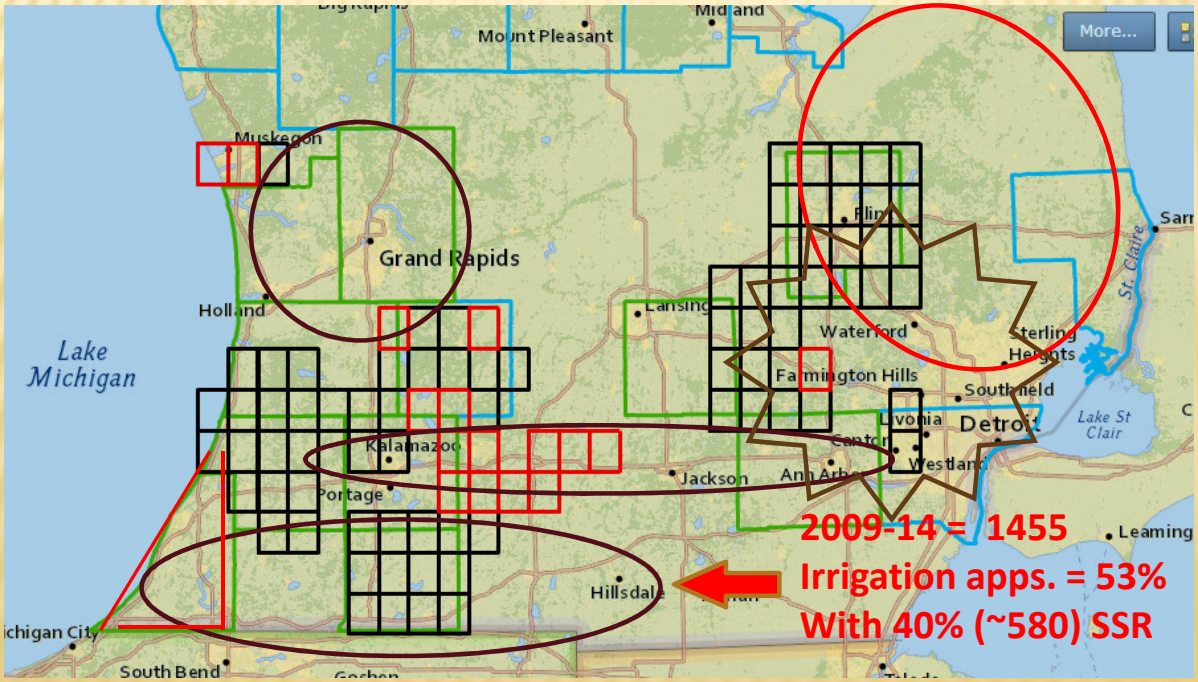
MICHIGAN CAN NOT GRASP RESOURCE ISSUES!

LP , Limited areas of more detailed mapping to date.,

Critical resource - areas identified are :(Brown, black or Red outlines) – So. Michigan Highway aggregate resources?

7/2009 to 7/2014 total 2716 - Water Withdrawal Assessment tool (WWAT) Irrigation applications for High Capacity (HC) wells >70 gpm.



Where is Geologic mapping data needed?

Mineral, aggregate need & availability?.

Mineral, aggregate & water data required.

Water quality and quantity?

8

STATE GEOLOGIC MAPPING

Not all Counties need detailed mapping today.

Typical LP County is approximately 10 to 12 Quads = 560 to 700 sq. miles. Mapping in the LP is predominately complex glacial terrain (<100 to >800 feet thickness).

Mapping will generate at least three qualified geologic products

- 1. aggregates, 2. minerals and 3. water resources

- Mapping in the UP is bedrock and glacial terrain.
  - 1. aggregates, 2. minerals and 3. water resources, plus
  - Identification of near surface geologic provinces for testing for potential metallic and non metallic mineral resources which, could result in development of an identified resource(s).
- Airborne geophysical surveys will enhance mapping, focus on details and will expedite target areas of importance in both the UP and LP, once validated airborne testing is completed.

9

MAPPING SUPPORTS SOCIETAL NEEDS

< 10 % of Michigan, primarily the LP, has been mapped producing validated geologic data available in ArcGIS files (State and Private Land), with some information on Federal (National Forest) property in the UP

Do we need to know the location of resources in the UP and LP?

GIS formatted validated geologic mapping products support:

- Aggregate locations & potential development statewide
- Water resources quantity and quality
- Identification of geologic environments for potential mineral resources (metallic and non metallic)
- Any business or economic development resulting in employment

Michigan has very little useable validated information?

MICHIGAN – MUST INVEST IN THE FUTURE

ROI – Validated

Mapping programs in Michigan, Kentucky and Ohio

- 1979 – The Survey mapped an area in Marquette County,
  - The result - the Eagle Deposit was identified,
- This was the last formal Survey mapping project in Michigan, over 30 years ago.
  - 500/300 jobs, >$100 million in tax revenue over 8 year life (Now expanded).
- Kentucky Survey completed geologic mapping of the entire State, Illinois survey conducted an economic study (1999).
  - The ROI was $25 to $39 for every mapping dollar spent = $2.2B to 3.5B.
- An economic study for Ohio Survey showed data acquisition and research results has an ANNUAL benefit of over $575 million.

11

MICHIGAN – MUST INVEST IN THE FUTURE

ROI – Map priority areas of Michigan

- USGS Fed matching funds have been available since 1993.
- Maximum Fed STATEMAP matching ~$250K to $300K/yr.
- Other states have received $3 to $4 mill, which was matched
  - $136,363 to $181,818 per year in Federal funds.
- Michigan for 22 yrs received ~$883,000 in STATEMAP funding .
  - Federal -$883,000 (Michigan match $0) = ~$40,136/yr.
- 2015, Michigan is trying to catch up, must prioritize areas (DEQ, DNR, MDARD), 2015, the first money in 22 years ($44,000)

LP priority counties est. total cost of ~$1.0 M/ county (10-12 Quads). (Could have done additional 12 to 20+ priority counties in last 22 years.)

Surface and subsurface mapping - UP / County ~ $500k.

- Goal is to maximize the mapping and scientific data acquisition.

12

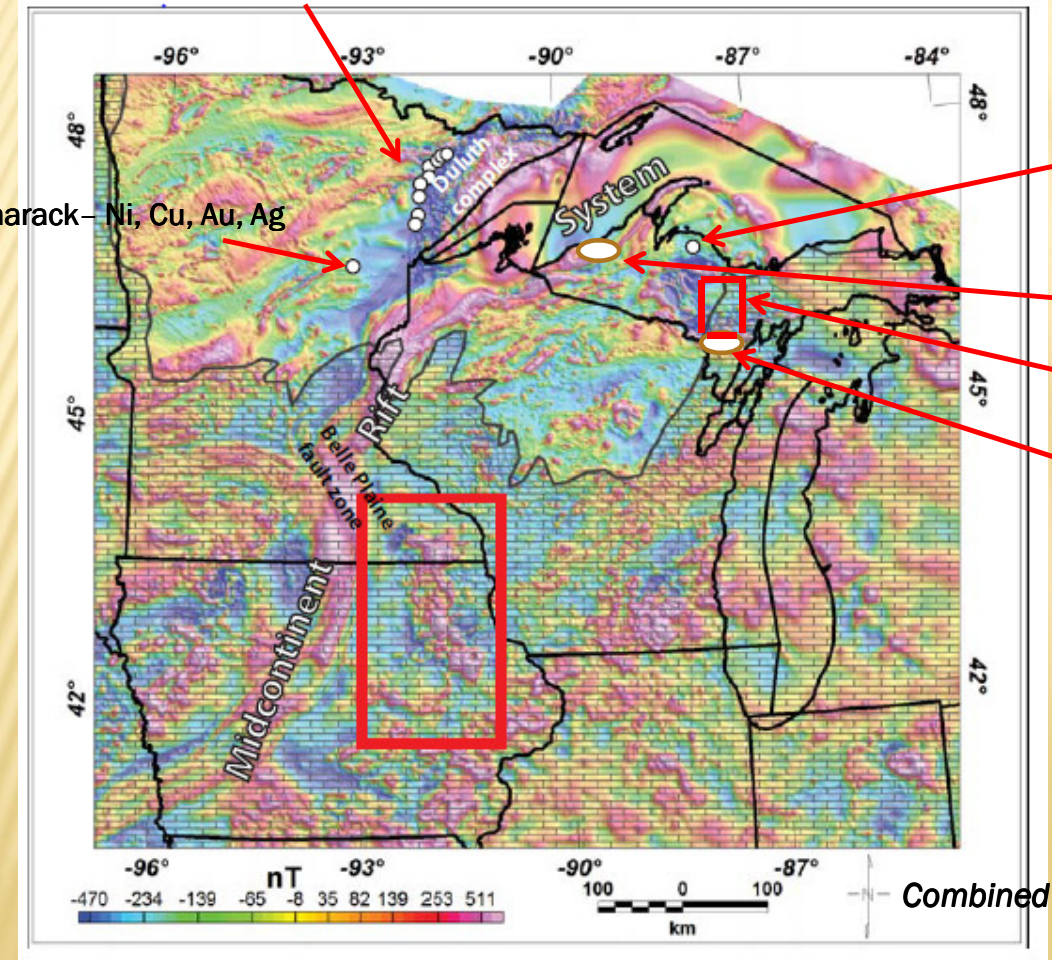
AIRBORNE GEOPHYSICAL SURVEYS – ROI

OVERVIEW:

- Minnesota invested $4.5M in 1979 to 1983 for airborne magnetics and re-evaluated and published all the data.
  - Resulted in multiple mineral discoveries of nickel, gold, silver and platinum group metals in rock types similar to Michigan.
- Rio Tinto discovery, Tamarack, 45 miles SW of Duluth, 4 years
  - Tamarack is similar to the Eagle Deposit in Marquette County
  - $1.6 million in leases
  - $4.0 million in spending in the local communities
- Michigan airborne magnetic data is not productive information.
- USGS is proposing a demonstration project for an area of the UP.
- Anticipating MGS, MTU and industry will provide some moral and "in kind" support.
- State economic development support is needed now?

13

AERO-MAGNETICS – INVESTMENT IN THE FUTURE



Tamarack– Ni, Cu, Au, Ag

Eagle – Ni, Cu, Au, Ag

Copperwood – Cu, Ag

USGS Aeromagnetic

Back Forty – Zn, Au, Ag

Michigan and some of the Wisconsin geologic environments are similar to Minnesota

Combined summary of aero-magnetic data

MAPPING MUST START WITH REAL DATA

Mapping needs boots on the ground plus, the following:

Prioritize areas by economic, societal and geologic need.

- Samples, core data, digital data – i.e. MGRRE repository
- Compiled & validated geologic data-Michigan files
- Determine where and what airborne surveys can expedite the assessments
- LiDAR is a major component of any airborne survey.
- All output will be in ArcGIS data sets

MGRRE*–SUBSURFACE GEOLOGY

- WMU-MGS APPLIED RESEARCH
- Industry and academic research for over 30 years

*Michigan Geological Repository for Research and Education (MGRRE) established in 1983

16

MGRRE - CORE/DATA REPOSITORY

- Data & samples from Oil, Gas, Mineral, Geotechnical, Environmental tests, Research and Water Wells,
- Over 500,000 feet of Core (95 + miles).
- Over 20,000 wells with sample sets,
- Tens of thousands of well reports, logs and chemical sample analyses in data bases, scanned/digitized.
- 2000 +Community water well samples

17

MGRRE –SUBSURFACE GEOLOGY

- MGS/WMU , MTU, USGS, DOE partnerships
- Industry, academic & student research and partnerships for over 30 years
- 27,000 sq ft (1/2+ acre)

MGRRE ➡ ECONOMIC DEVELOPMENT

ROI - Industry & Academic Milestones

- MTU-WMU partnership – DOE grant for the application testing of horizontal drilling technology to develop Michigan oil in **1995.**
- PTTC Research & conferences over 20 years, industry, WMU, DOE/Government
- USGS data compilation of oil basins, MGRRE core led to Trenton Black River – + 3D, rediscovery in **2006** of 5 + fields + 5 M bbls oil (+$21M tax rev).
- Collingwood, Utica and A-1 Carbonate studies - $178 M lease sale, the largest in Michigan history, + 3D, which led to new exploration success in **2010**.
- DOE - CO2 Sequestration program for 9+ years – **2005 - present.**
- EOR with CO2 – Core samples lead to program testing + 3D, and successful tax reduction legislation – **2005 to 2014** with est. 1.6 m bbls produced ($7.3M tax rev).
- Re-discovery of a potash resource, Mecosta – Osceola Counties (~$65B) - **2013**.
- Many WMU Geoscience graduates ➡ professional positions

No Research funding from the State has been received by MGRRE/WMU as a result of these milestone State economic & employment events.

19

WHERE WOULD YOU FIND GEOLOGIC DATA?

DID YOU KNOW THERE IS NOT A DATA BASE THAT LINKS GEOLOGIC DATA TO EACH STATE AGENCY?

- OVER 7000 + Community drinking water supply wells - (DEQ). Drilling and pumping data on aquifers,
- Water quality sampling – statewide by Cities, Counties, etc.
- Michigan contaminated sites Clean up program - (DEQ-RRD).
  - (PART 201- PART 213) – Thousands of contaminated sites.
  - Drilling, sampling and hydrogeologic studies for remediation.
  - Estimate over 600,000 holes having geologic data.
- MDOT Drilling for road construction, thousands of holes .
  - MDOT – Geotechnical and Phase I and II reports
- MDNR Drilling for construction and assessment of State property and facilities.

20

WHERE WOULD YOU FIND GEOLOGIC DATA?

- 751 – EPA - UIC Class I and Class II wells, > 1000 feet deep
- 78 LICENSED LANDFILLS IN MICHIGAN, Decades of Data - 30+ YEARS
  - ~60 Landfills are closed and are being monitored for life
- OIL WELLS DRILL through glacial material (DEQ-OOGM) – 60,000+

All equals ~ 1,000,000 Real geologic data points, NOT BEING USED.

- Not until 7-2014, DID ANYONE DISCUSS THESE SOURCES - MGS

None of these data resources talks to each other and most of the data is in paper files, except DEQ-OOGM.

"Orphan Data"

MGS is presenting a demonstration project for developing a shared data base for geologic data

21

ACCELERATE THE START WITH REAL DATA

Michigan – a paucity of real data for mapping

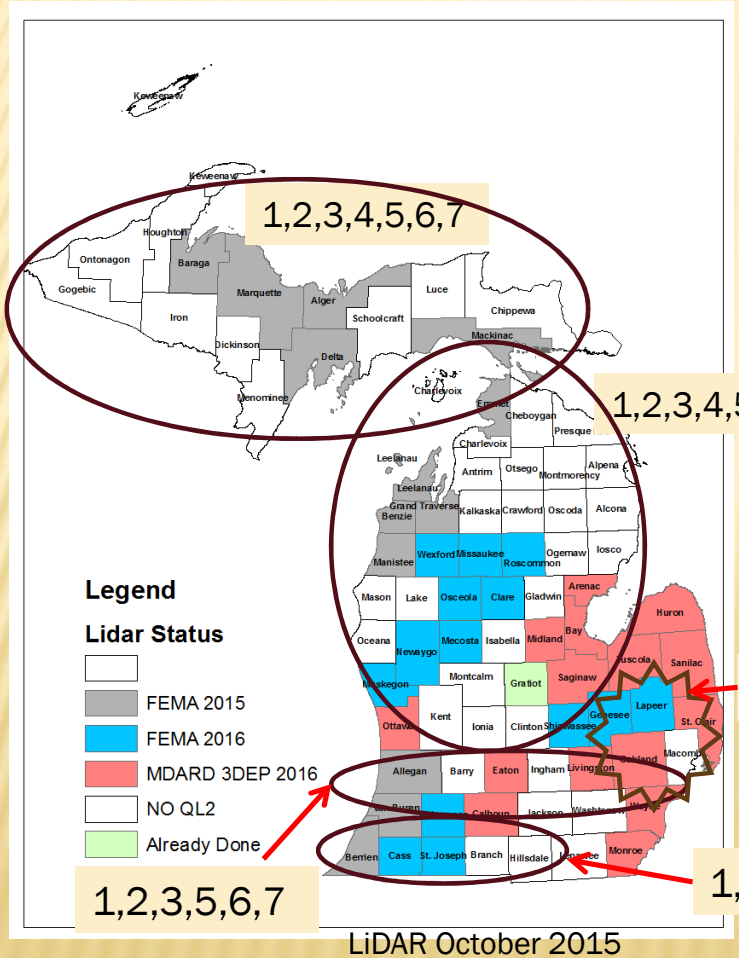
- One of two Great Lakes states that has NOT conducted a Statewide LIDAR program
- Most Great Lakes states are in their second and third LiDAR phase
- Limited LiDAR by Counties, USGS shared funding (8 yr), is a great start and MGS applauds USGS for their efforts
- DTMB is proposing MiSAIL, a program that needs funding
- FEMA and DEQ are funding mapping of critical areas
- The entire State needs LiDAR QL-2
- Limited benefit to QL-3, unless there is little vegetation
  - Must focus on flying when there is limited vegetation

22

MICHIGAN – PAUCITY OF USEABLE LIDAR TO SUPPORT SCIENCE AND ANY MAPPING

- All State and local government agencies can use LiDAR data
  - MDARD - Soil conservation- Agriculture,
    - Including Federal Natural Resources Conservation Services (NRCS),
  - MDOT - Highway Construction,
  - MDNR - Forestry and Property Management,
  - MDEQ – Resource permitting, assessments, dams, etc.
  - Geological Survey (MGS) - Mapping of surficial geology, natural resources,
  - Management of any development (City, Twpshps, County, State)

USEABLE LIDAR IN LP AND UP OF MICHIGAN

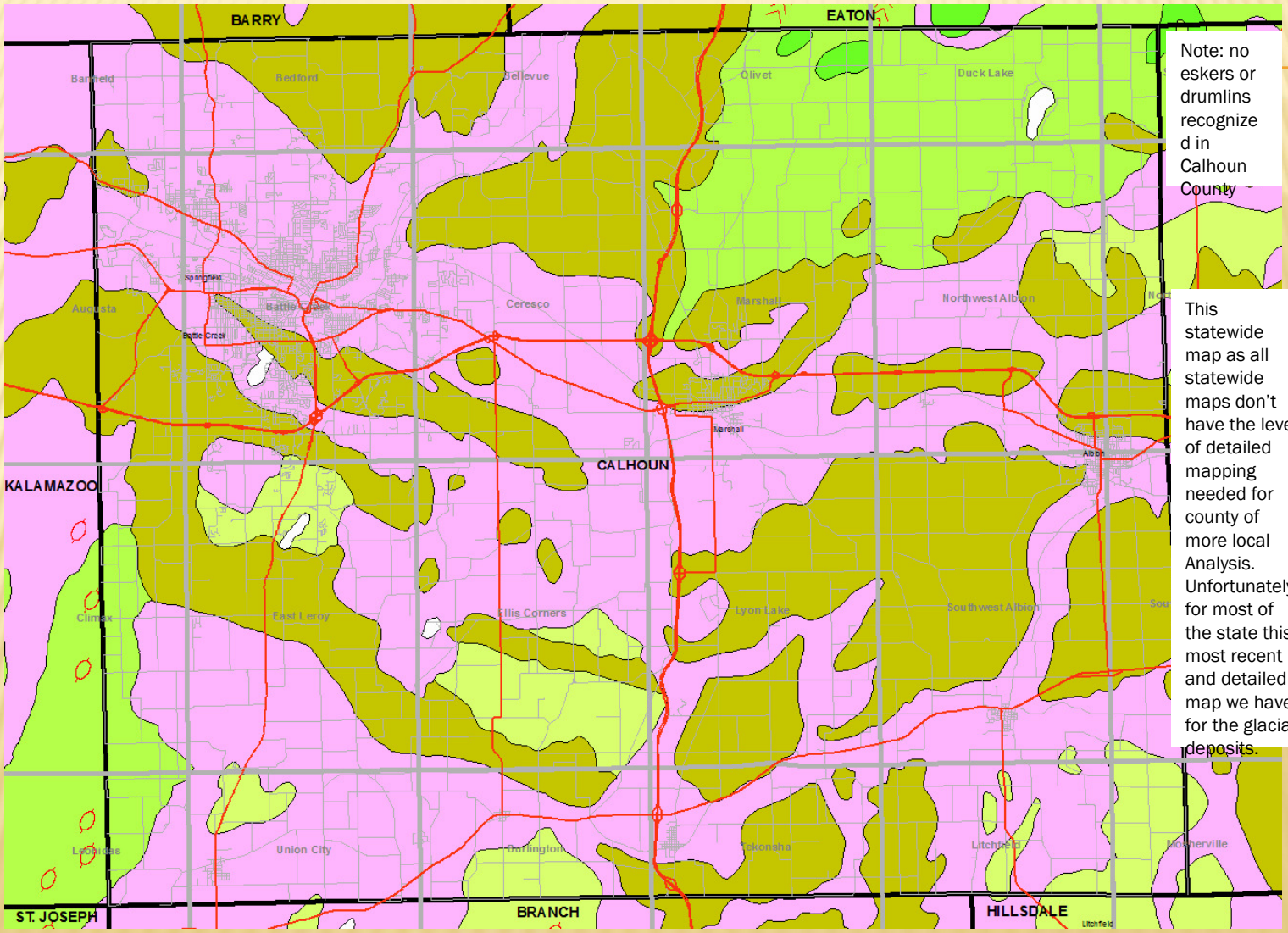


LiDAR October 2015

Recommended areas of importance to support all State programs:

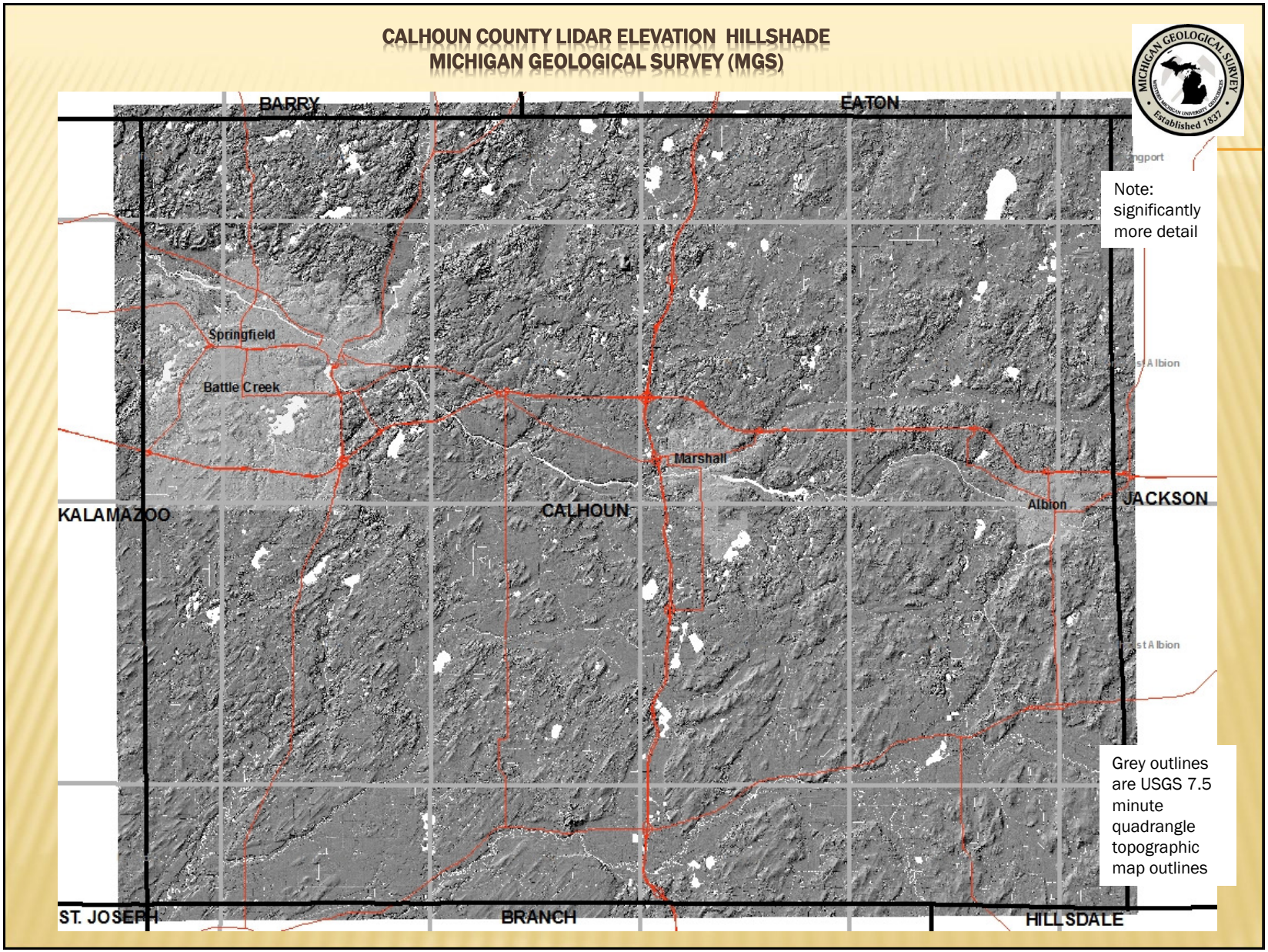
1. MGS Mapping & MDEQ
2. MDARD Agriculture
3. MGS Resources & water assessments
4. MDNR Forestry
5. MDOT Highway construction
6. Aggregate locations
7. All Development

1982 QUATERNARY GEOLOGY MAP OF MICHIGAN 1:500,000 – BASED MOSTLY ON EARLIER MAPS FROM 1915 AND 1955

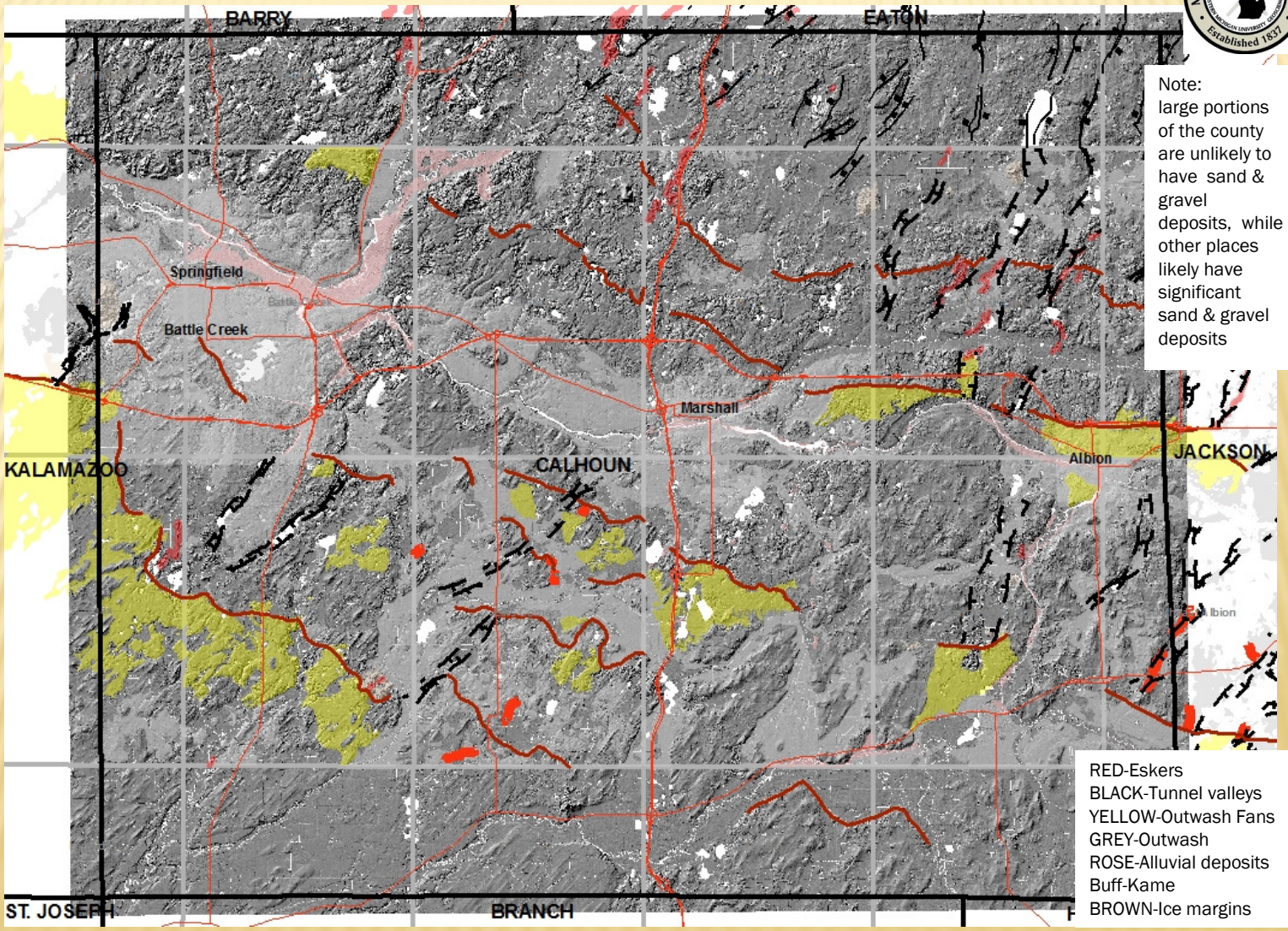


Note: no eskers or drumlins recognized in Calhoun County

This statewide map as all statewide maps don't have the level of detailed mapping needed for county of more local Analysis. Unfortunately for most of the state this most recent and detailed map we have for the glacial deposits.


CALHOUN COUNTY LIDAR ELEVATION HILLSHADE
MICHIGAN GEOLOGICAL SURVEY (MGS)
BARRY
EATON
Springfield
Battle Creek
Marshall
Albion
KALAMAZOO
CALHOUN
JACKSON
ST. JOSEPH
BRANCH
HILLSDALE
Note: significantly more detail
Grey outlines are USGS 7.5 minute quadrangle topographic map outlines

2015 QUATERNARY GEOLOGY MAP OF CALHOUN COUNTY – SAND AND GRAVEL LIKELY BEARING GLACIAL LANDFORMS OVER LIDAR HILLSHADE

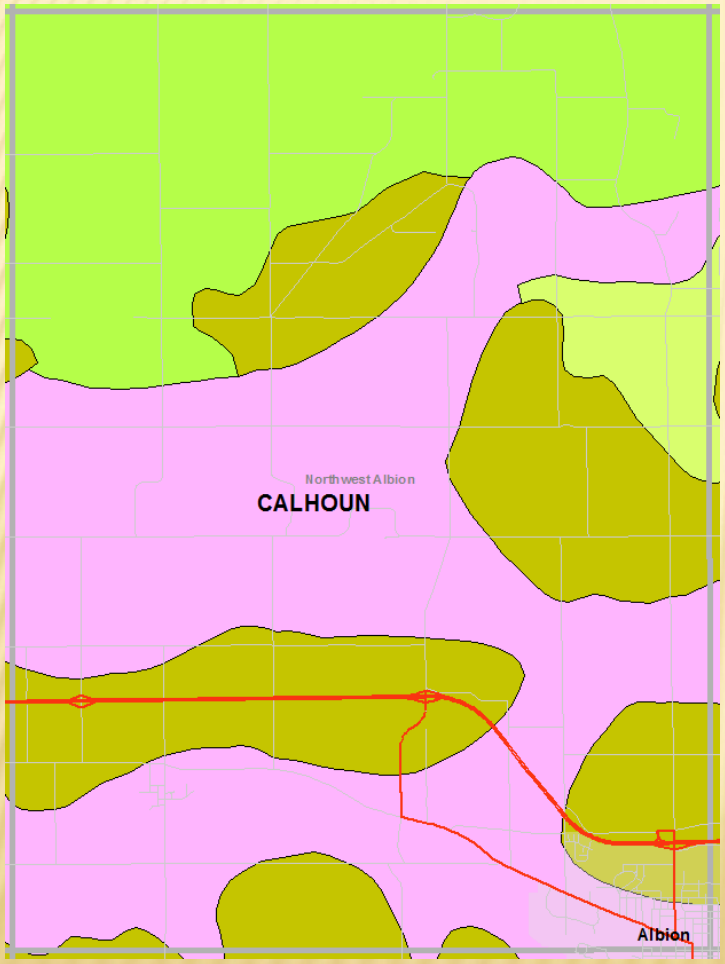


Note:
large portions of the county are unlikely to have sand & gravel deposits, while other places likely have significant sand & gravel deposits

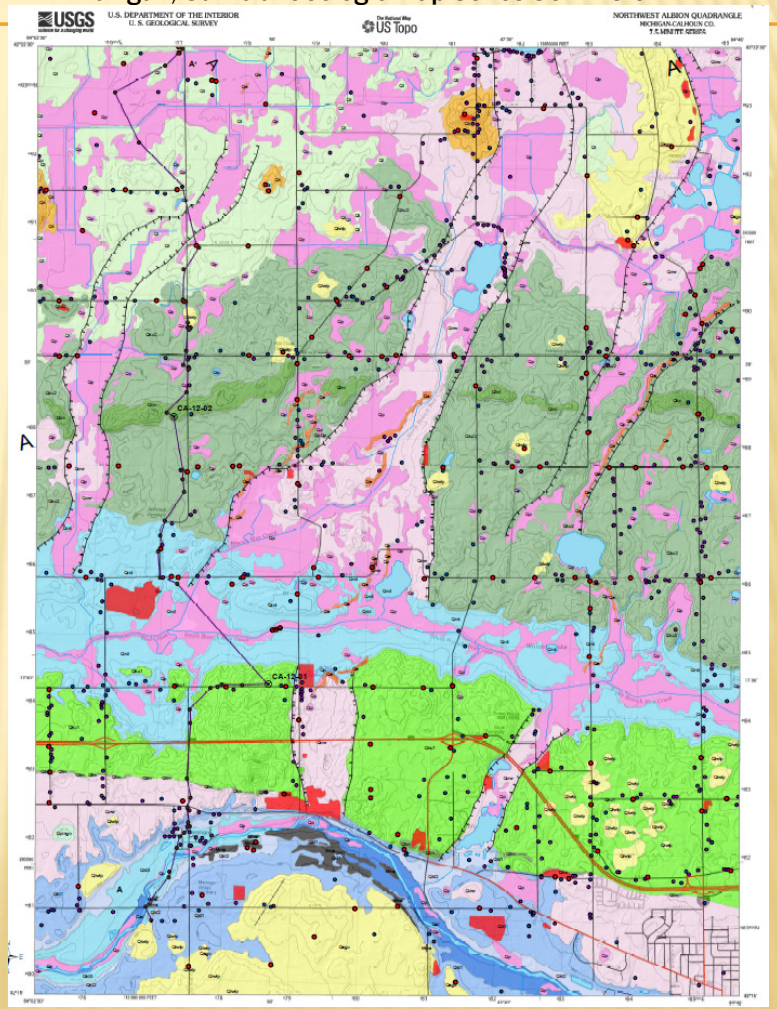
RED-Eskers
BLACK-Tunnel valleys
YELLOW-Outwash Fans
GREY-Outwash
ROSE-Alluvial deposits
Buff-Kame
BROWN-Ice margins

COMPARISON OF THE DETAIL IN THE 1982 STATEWIDE MAP VERSUS A RECENT DETAILED GEOLOGICAL MAPPING EFFORT BY THE MGS

1982 Quaternary Geology Map of Michigan 1:500,000 – statewide map zoomed in the to NW Albion 7.5 minute quadrangle



Michigan Geological Survey 2013, Surficial Geology of the Northwest Albion 7.5 Minute Quadrangle, Calhoun County Michigan, Surficial Geologic Map Series SGM-13-02

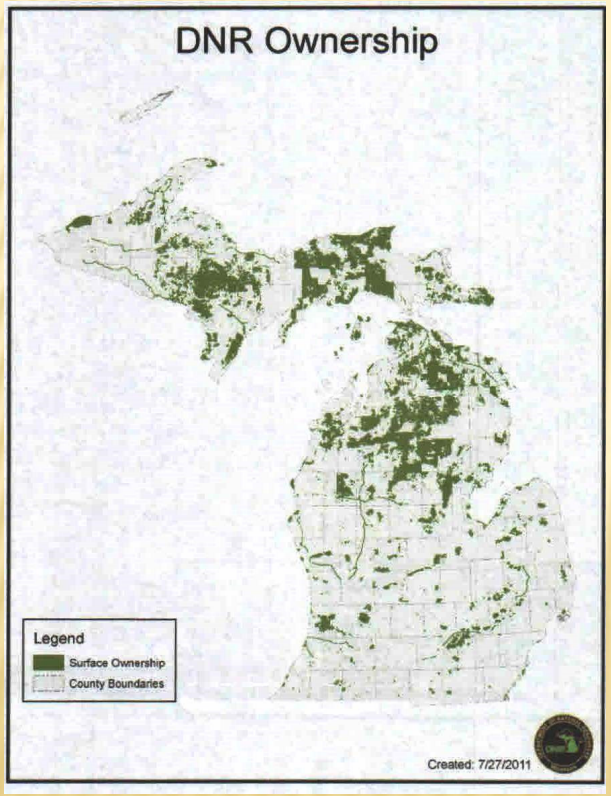


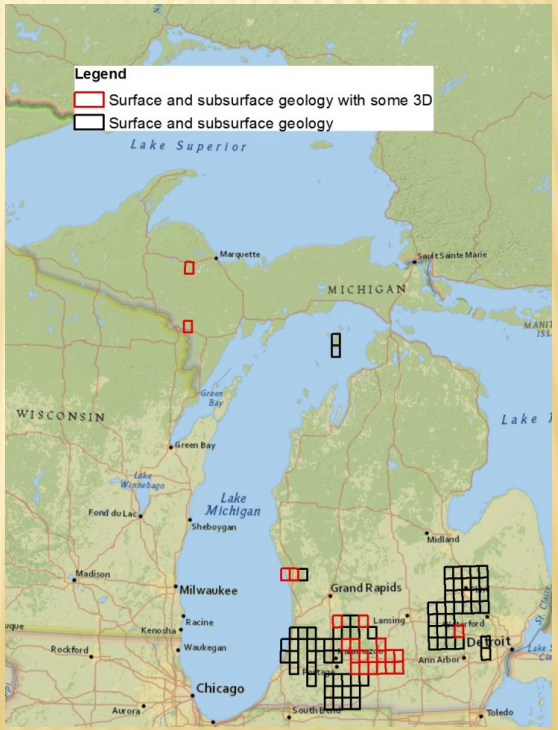
MICHIGAN MUST INVEST IN THE FUTURE

Summary of assets vs Validated Mapping info

STATE LAND MANAGEMENT

~4.5 MILLION ACRES





MAPPING – TO INVEST IN THE FUTURE

STATE – SUMMARY OF ASSETS

- Forests, Parks, Fisheries, Wildlife management
- Less than 10% of Michigan subsurface has been mapped in any detail
- Michigan does not have a geological understanding of these resource assets!
  - Aggregates
  - Water withdrawals in critical area(s)
  - Mineral resources (Metallic and Non-Metallic)
  - Wetlands
  - Water recharge
  - Best Management practices for the assets
  - ENERGY RESOURCES- the only asset to have benefitted from data collection and management through the Office of Oil, Gas and Minerals (OOGM), tied to MGRRE/MGS for the last 30 years.

30

MICHIGAN GEOLOGICAL SURVEY

Your comments and thoughts?

Thank you

Questions?

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